Chapter 7

Air Control

CHAPTER 7 AIR CONTROL

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CHAPTER 7

AIR CONTROL

7.1 GENERAL

Air trapped in a stockwater pipeline can reduce or even completely stop the flow of water in the line. This is particularly a critical problem in pipelines that operate under very low heads or in long pipelines.

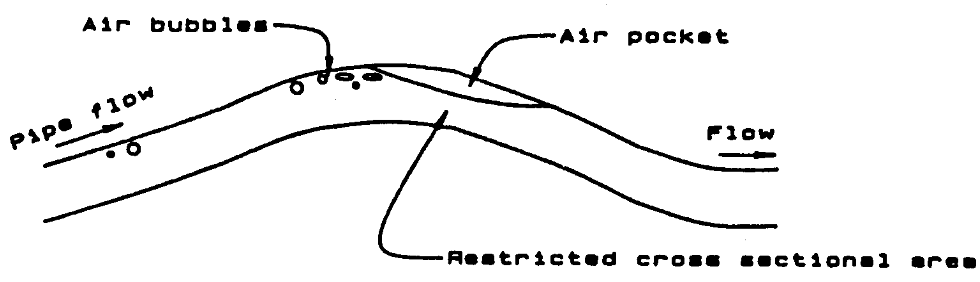
7.2 AIR/GAS PROBLEMS

Air or gas gets into a pipeline in several ways. These include:

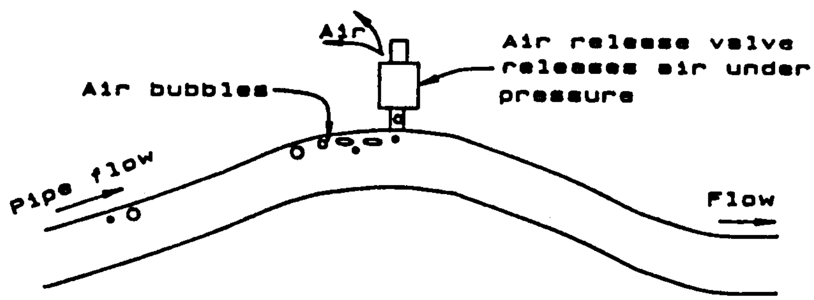
- When a pipeline is drained, air enters the line through hydrants or any opening.
- There are various forms of gasses in well waters. These gases can come out of solution during pipeline operation. Some wells have more serious gas problems than others.
- If the water level in a well or other source falls below the pump intake, air is drawn into the pipeline by the pump.
- In gravity systems, air can be drawn into the pipeline when water surface falls below the pipeline entrance. In some live streams, there can also be air bubbles entrapped in the water.

Figure 7.1 illustrates what happens when air is trapped at a high point in a pipeline. A bubble is formed at the high point. The effect is to reduce the cross-sectional area of the pipeline and thus restrict flow. This has the same effect as inserting a short length of small diameter pipe in the pipeline. Velocity accelerates through the smaller section of pipe and friction loss is increased. Since friction loss is a function of the square of velocity, friction loss can increase drastically when a large bubble is present. If the bubble is big enough, or there are many of them, flow can be cut off completely.

Figure 7.1
RELEASING AIR FROM PIPELINE



NO AIR RELEASE



WITH AIR RELEASE VALVE

* In addition to the flow restriction they cause, air pockets can react in a way that aggravates water hammer problems.

As velocity increases, the air pocket tends to be pushed down the pipe in some sort of elongated bubble. There may be several separate bubbles formed. If velocities are high enough, and elevation difference to the next low point is not too great, the bubble may be pushed through to the next high point or outlet.

*** NEBRASKA NOTE**

Large air pockets can aggravate water hammer problems if they are released from the pipeline too quickly. As large volumes of air are released from the pipe, the water will rush to fill the void caused by the released air. The velocity of the water can be very high and the sudden closing of the air valve can result in water hammer and high surge pressures. The minimum air release orifice size specified in FOTG Standard 516 should be used as the design orifice size.

7.3 AIR IN LOW HEAD GRAVITY PIPELINES

Air locks are a frequent problem in very low flow, low pressure pipelines. An example of this type of system is a spring fed installation. In this case the velocity of water is very low. Air bubbles do not get pushed out, even if the summit in the line is only one pipe diameter above the rest of the line.

The solution for air lock problems can be either of the following:

- Install an open air vent at all summits in the line. Figure 3.1 in Chapter 3, illustrates an example of this type of pipeline system.

- Install the pipe so there are no summits in the line. Carefully lay out the pipe so it is on either a constantly increasing or decreasing grade.

For very low pressure pipelines, experience indicates that minimum pipe diameter should be:

1-1/4 inch nominal diameter for grades over 1.0 percent.
1-1/2 inch nominal diameter for grades from 0.5 to 1.0 percent.
2 inch nominal diameter for grades from 0.2 to 0.5 percent.

For grades less than 0.2 percent, gravity flow systems are not recommended. Where pipe of minimum size will not deliver the required flow, the size should be increased.

Cleaning may be made easier by placing "T's" or "Y's" with plugs at strategic points in the pipeline.

Outlet pipes from a spring box should be placed at least 6 inches above the box floor to allow for sediment storage. A tee and vent pipe or a screen should be installed on the pipe within the spring box to reduce plugging by leaves and trash.

Pipes starting at storage tanks or ponds should be screened and placed far enough above the tank bottom to prevent sediment from entering the system. Screens should be made of copper, plastic, or stainless steel. A swivel-elbow arrangement connected to a float will alleviate both bottom sediment and surface trash problems associated with ponds and large open storage tanks.

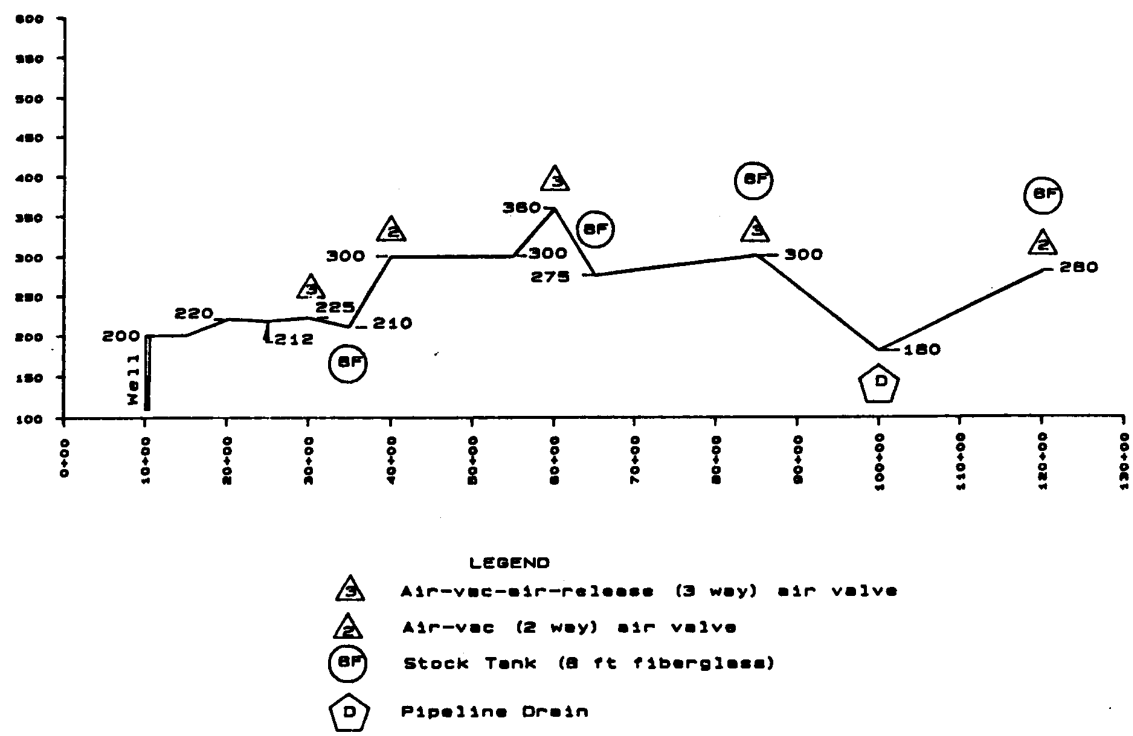
7.4 AIR CONTROL IN HIGH HEAD, LONG PIPELINES

There are two ways to resolve air problems in high pressure pipelines:

- Minimize the number of summits in the line by meandering the pipeline along the contour to avoid high points. There is a point where the extra cost of additional pipeline length makes this a non-cost effective approach.

- Install air valves at summits to control the entry and exhausting of air. Figure 7.2 shows this type of installation.

Figure 7.2
TYPICAL SYSTEM WITH AIR VALVES

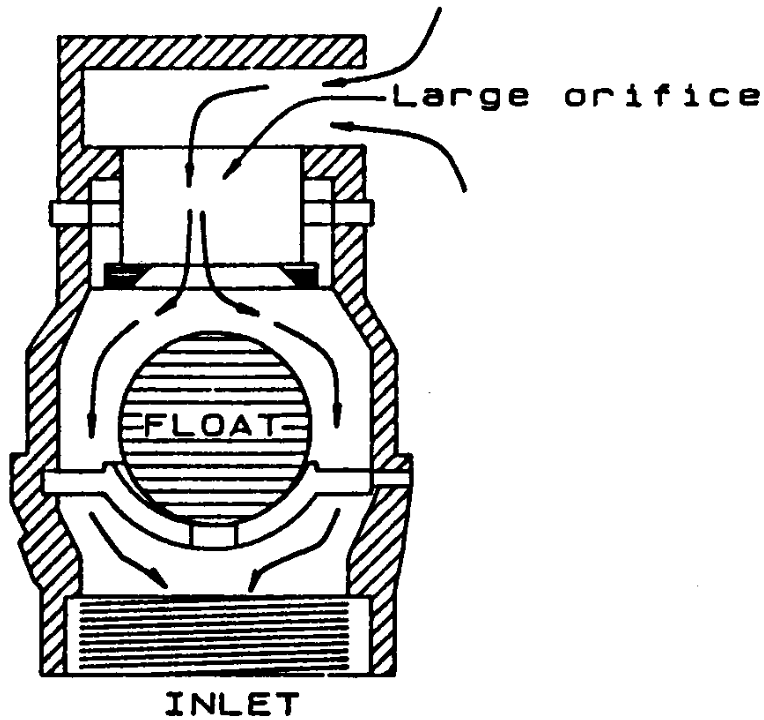


There are three types of functions that air valves perform:

1. When a pipeline is emptied, air must enter the line some place. If provisions are not made for entry of air, a vacuum can be created in the pipeline. This can lead to collapse of the pipe or at least breaking of the water column, which creates gas or water vapor pockets in the pipeline. Although it is unlikely that the small diameter pipe in stockwater lines will collapse due to vacuum, it is a bad design practice to allow significant vacuum to develop in the pipeline. It is therefore important to have a vacuum relief mechanism at significant high points in the line.

   Figure 7.3 illustrates how a typical air valve takes care of this function. Since there is no water in the valve chamber, the float drops on to a cage and allows air to enter the large orifice.

Figure 7.3
VACUUM RELIEF



2. When an empty pipe is filled with water, air in the line must be released in large volumes. This can be done by leaving the hydrants open. But what if the hydrants are closed? Air pressure will build up in the pipeline. When a hydrant or float valve is opened, high pressure air will escape and then, when water hits the end of the line, water hammer will probably occur.

   For adequate system protection, there must be a mechanism to automatically release large volumes of air from the pipeline during filling. For best results, the mechanism should be located at all significant summits in the line.

   Figure 7.4 illustrates how a typical air valve takes care of this function. Since water has not yet entered the valve chamber, the float stays down on a cage. Large volumes of air escape through the large orifice.

   When the pipe fills, the float floats to the top of the valve and closes the large orifice. The valve then remains closed until the pipeline is again empty. The float will not drop unless pressure drops to zero, since pressure keeps it jammed against the orifice. This is the case even if an air pocket builds up in the valve chamber during operation.

   Figure 7.5 illustrates the closed valve.

Figure 7.4
RELEASE OF LARGE VOLUMES OF AIR DURING FILLING

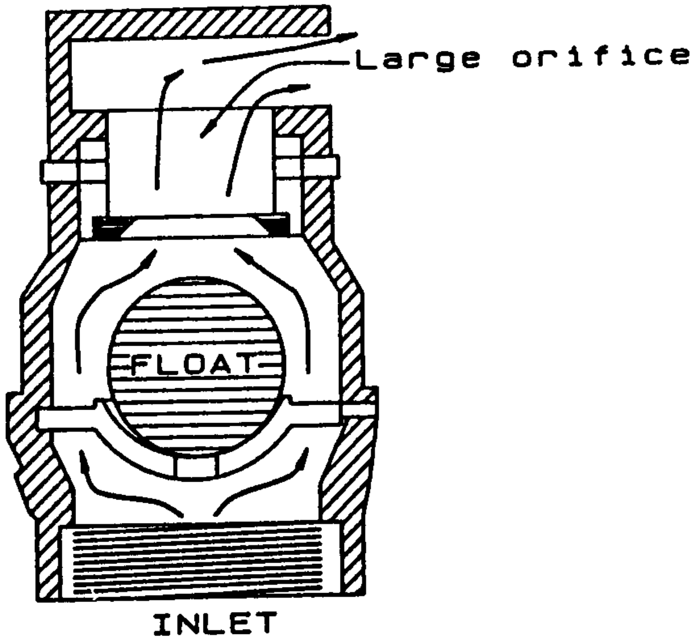
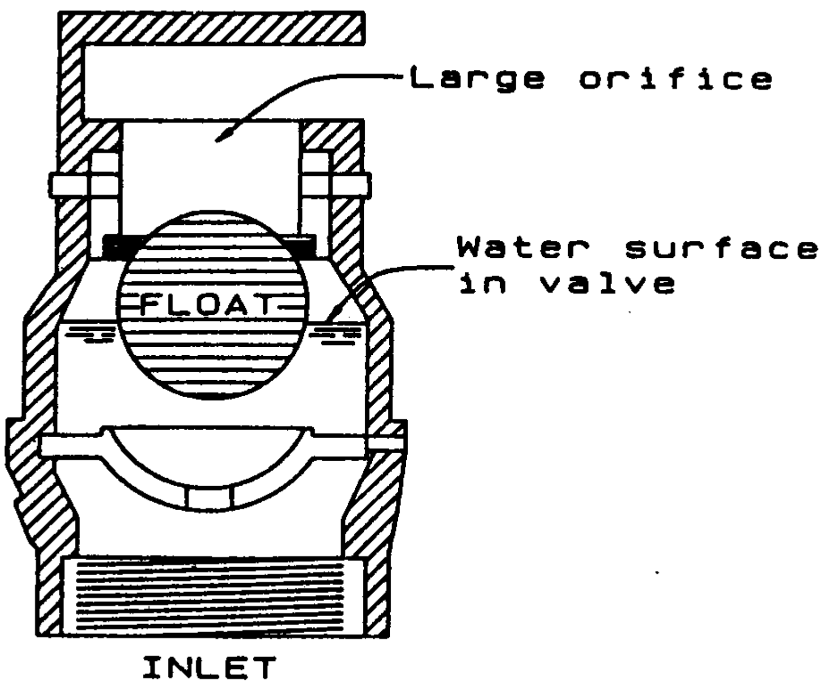


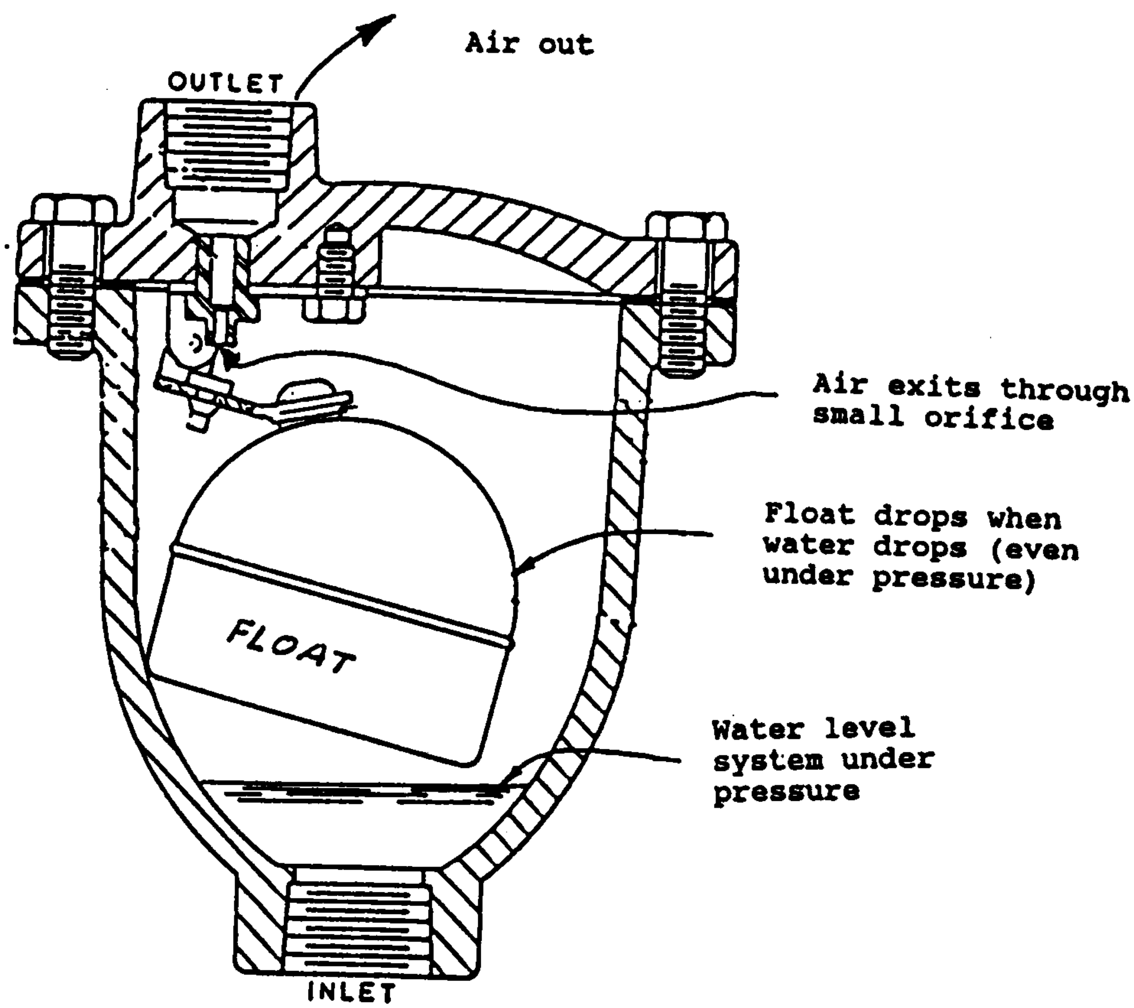
Figure 7.5
WATER AND PRESSURE KEEP FLOAT VALVE CLOSED



3. During operation of the pipeline, air bubbles and other gasses come out of solution and buildup as gas bubbles at summits in the line. There are usually also remnants of the large volumes of air present immediately after filling. If the summit is high enough, this air will never push on through the line. Gases may eventually buildup to the point where the flow rate is seriously reduced or flow may even stop. It is not possible to predict how serious a problem this may be when designing a pipeline.

   Figure 7.6 illustrates how a typical air release valve works. A heavy float and a small orifice allow the float to drop and open the orifice even when the system is under pressure. So when air bubbles gravitate to the air chamber, and the float drops, high pressure air is expelled from the valve.

Figure 7.6
AIR RELEASE VALVE
FOR RELEASING AIR WHILE PIPE IS UNDER PRESSURE



In the past, there have been long high pressure stockwater lines installed in Montana with little or no provision for air venting. Many of these systems work. A line that has worked for years will sometimes slow down or stop. The usual culprit is air in the line.

Long stockwater pipelines cost a lot of money. The cost of installing adequate air handling equipment during initial installation is a relatively small part of total installation cost. The cost of installing air valves is much less in the initial installation than going back later to add needed valves. Adequate air handling equipment should always be designed into a system at the time of initial installation.

In high pressure, moderate flow systems, there are frequently many small undulations in the ground surface and a few large humps. Trial and error on typical long stocklines in Montana has led to the conclusion that we can usually get away with not installing air vents or valves on summits that are less than ten feet high. So in most cases, it is recommended that air handling equipment be installed on all summits of ten feet or more, at the end of the pipeline and at the first high point of any kind past the pump.

Ignoring summits which are less than ten feet may occasionally lead to system operational problems. In that case, the owner will have to go back and install air valves or vents at all summits. So far, the risk involved in using this rule of thumb has proved acceptable. Remember that it is not acceptable to ignore summits in the line in low head, low velocity pipelines.

A particularly important location for a continuous acting air release valve is the first high point past the pump. This valve would catch and release most gas introduced at the pump.

The preferred locations for air venting is at high points in the line. Hydrants, open vents, or vacuum relief valves can be used. Where the hydraulic grade line is close to pipe elevation, open air vents are the best choice. Hydrants can be used if they are always opened at the time of draining. The risk of using hydrants is that there may be additional damage to the line if a sudden pipeline break should unexpectedly drain the line.

7.5 HOW AIR VALVES WORK

There are four general types of air valves. They are:

1. Vacuum relief valve (relieve vacuum only)

2. Air relief/vacuum relief valve (relieve vacuum and expel large volumes of air during filling)

3. Air release valve (release small volumes of air under pressure)

4. Combination air/vacuum relief, air release (combines all functions in one valve).

7.4A AIR CONTROL IN HIGH HEAD, LONG PIPELINES

High Pressure Systems:

The Nebraska guidelines for the installation of air release valves are similar to the Montana guidelines.

A continuous acting (3-way valve) should be placed at the first summit in the line. This valve will release the air injected into the pipeline by the pump.

An air/vacuum (air/vac) relief valve should be considered for summits with a combination of a rise in elevation of 25 feet or more and a fall in elevation of 25 feet or more.

For pipelines larger than 1-1/4 inch diameter, stronger consideration should be given to installing air relief valves at smaller summits. Because the velocity in larger diameter pipelines is slower, less air bubbles will be carried from higher peaks. By installing additional hydrants or valves, the potential for air entrapment problems is reduced.

NOTE: The above guidelines for placement of air/vac relief valves will suffice for most livestock systems. However, long pipelines, pipelines installed in undulating terrain, or pipelines with long intervals between valves or tanks, may need additional valves. For these situations, contact the area engineering staff for assistance.

Gravity Flow and Low Pressure Systems:

Pipelines with low operating pressure or gravity systems should have air/vac relief valves installed at all summits. Gravity systems should also have an air/vac relief valve or vent installed at the inlet of the pipeline.

The latter three types of valves are usually used in stockwater pipelines. The smallest valves available are usually adequate. Valves are rated according to maximum pressure that they can operate under as well as by orifice size. Only appropriate pressure rated valves should be used.

Figures 7.5 through 7.9 illustrates cutaway views of typical air valves used in stockwater pipelines. Different manufacturers have different ways of doing the same job. Some valves are made of plastic. These generally are adequate for low pressure operation. The cast iron models are for high pressure operation.

It is sometimes claimed that the air release (small orifice) valve will also serve the purpose as vacuum relief valve. The small orifice is not adequate to prevent high vacuum from occurring if there is a sudden break or during emptying of the pipeline. The proper kind of valves should be used where they are needed.

In most cases, the combination (three way) valve should be installed at all significant summits. An air release valve will suffice at small summits. At the end of the line an air release/vacuum (two way) valve should be installed.

Figure 7.7
TYPICAL AIR RELEASE VALVES

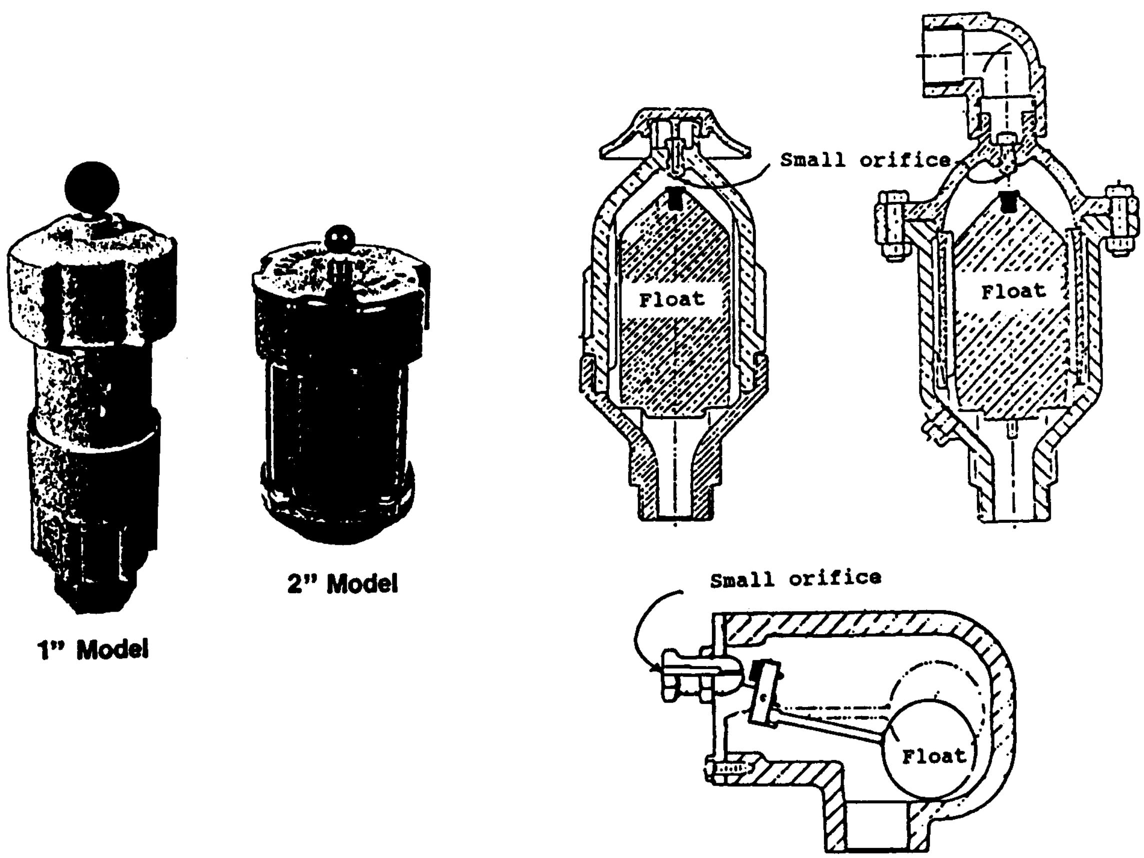


Figure 7.8

TYPICAL AIR RELIEF/VACUUM VALVES (TWO WAY)

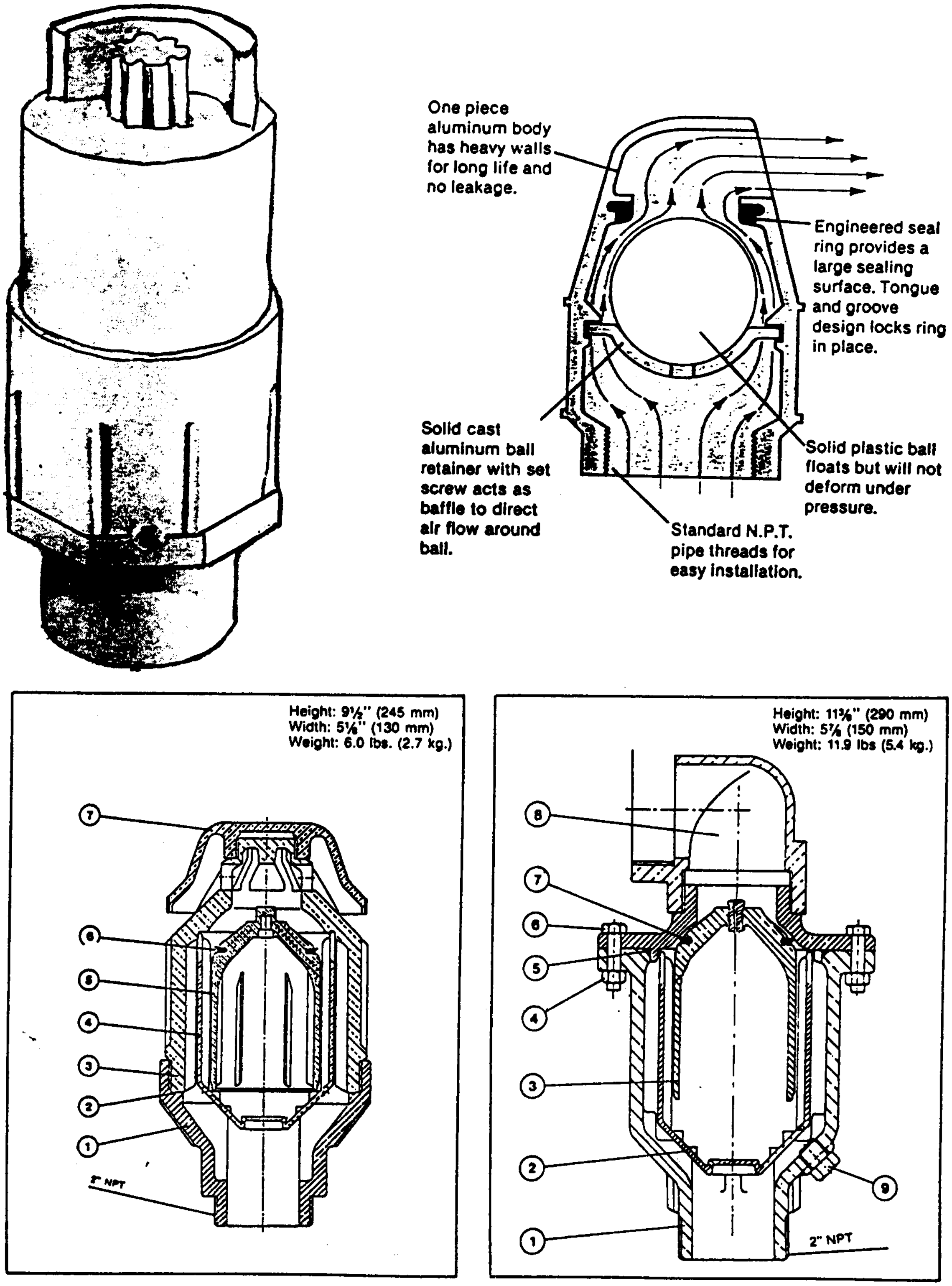
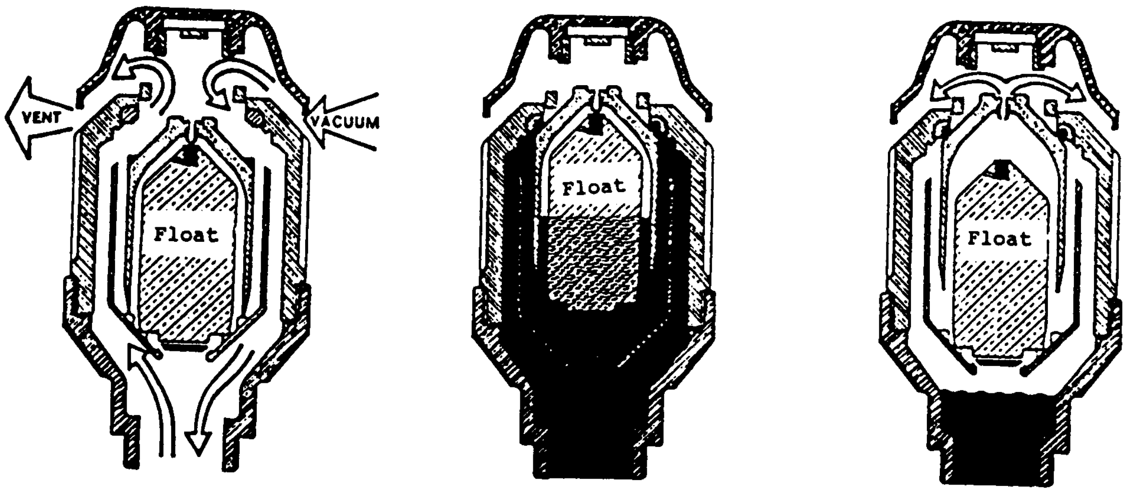
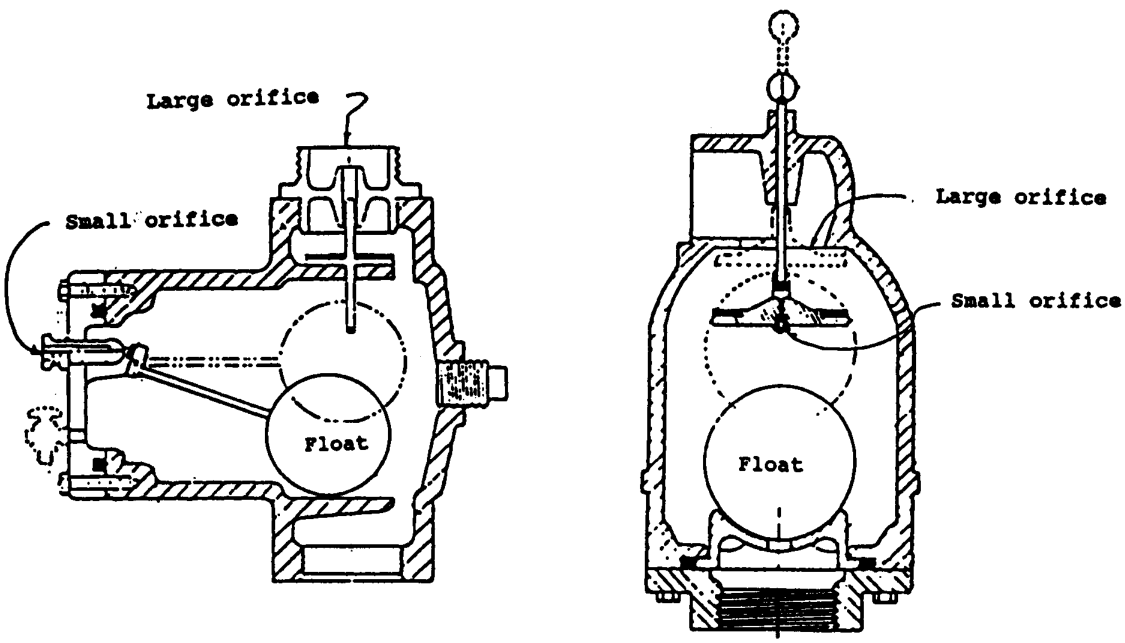


Figure 7.9
TYPICAL AIR/VAC/AIR RELEASE VALVES (THREE WAY)



Open Closed Pressure air release



7.6 AIR VALVE INSTALLATION

Figure 7.10 illustrates a good air valve installation. Since air valves can leak some water, provisions must be made to dissipate this water.

Figure 7.10
AIR VALVE INSTALLATION